MANURE:

Its Management In BARN AND FIELD

By

J. A. SLIPHER

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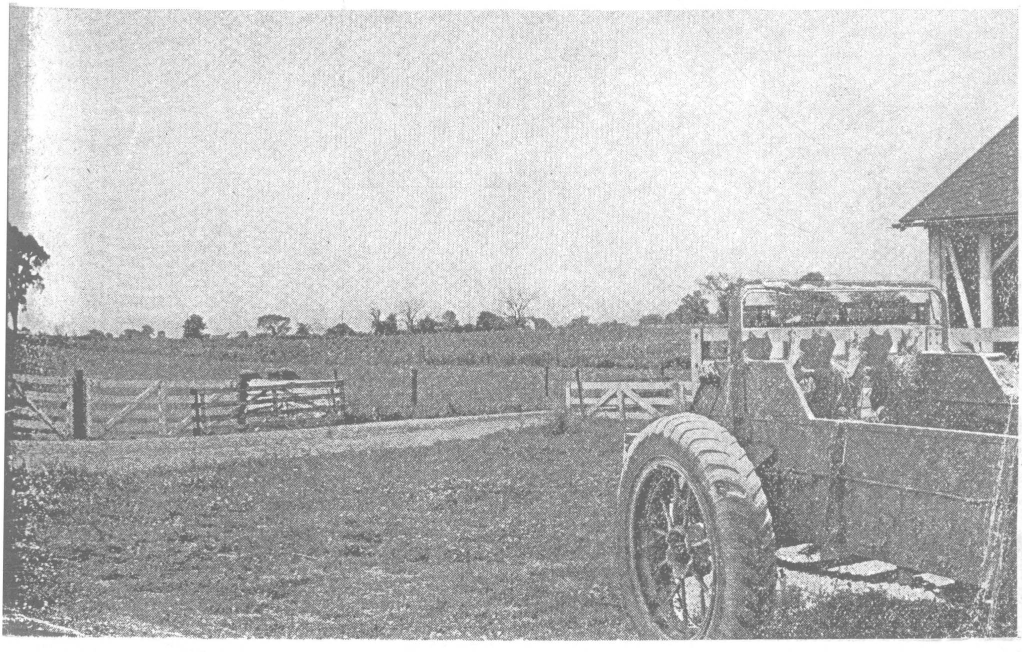

The Challenge

Getting full worth out of the manure supply is a measure of the farmer's ability as a farmer.

A Farm Product of Worth-while Value—

The barn manure product of the state is worth more than two Ohio wheat crops.

A ton of unwasted manure is worth $3 to $4; that is, it will produce crop increases of that value.

But Manure is Perishable—

Fully one-half the wealth in manure never reaches the field, due to heavy leaks during production and wasteful aging after production. Ohio's yearly waste of manure would comfortably pay two-thirds of her farm taxes.

Deterioration of Manure is Preventable.

The means are—

—chiefly judgment and foresight
—timely management
—labor applied at most effective time
—modest outlay in equipment

Safe Protection is Simple, Practical, and Profitable—

Money put into protection returns two- to three-fold.

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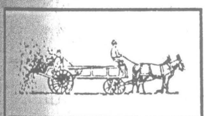


Much wealth reposes in manure. To get it out requires good management. To lose it is easy, for manure is perishable. Unless safeguarded, manure will lose fully one-half its crop producing strength before reaching the land. By employing proper protective measures at the barn and by wise handling in the field, manure can be made to deliver its maximum to soil and crop.

AVERAGE MANURE WORTH $2.50 A TON

A ton of average manure is worth from $2 to $3. This is not a theoretical valuation. It is a field valuation of the actual crop-producing power of manure as measured by crop responses in field tests. Findings in thirty-one manurial experiments in Ohio, involving all field crops grown on thirteen extensive soil types and covering as many as 30 years in some instances, show that 1 ton of manure produced crop increases worth $2.50 (Figure 1). This represents an average of manures of many conditions, ranging from fresh to weathered and aged. Exposed and wasted manures fell $1 under this average. However, fresh or protected manures rose $1 or more higher than the average.

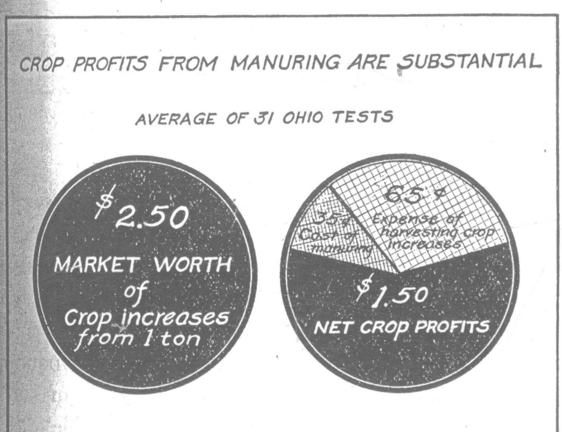


FIGURE 1

UNWASTED MANURE WORTH MOST

Fresh and unwasted manures yield the most substantial returns. Shed-protected manure applied at the rate of 5 tons on corn in a corn-wheat-clover rotation on Miami silt loam (buff or tan colored soil) of the Southwest Test

The author thanks E. P. Reed and F. J. Salter for their critical reading of the revised manuscript of this edition.

Farm, Germantown, raised the yield-level by 18 bushels of corn, 5 bushels of wheat, and 400 pounds of clover hay.

Evaluated at Ohio farm prices* for 1930-1931, these responses have a combined market value of $18 for the rotation or $3.50 for each ton of manure, as diagrammed in Figure 2. This may be regarded as a fair index to manurial returns on the light colored lands of western Ohio.

Protected steer manure used on corn at the rate of 8 tons in a corn-wheat-clover rotation at the Ohio Experiment Station, Wooster, brought responses of 24 bushels of corn, 10 bushels of wheat, and 1280 pounds of clover hay. In this 26-year test on Wooster silt loam soil, a yellow-brown soil typical of northeastern Ohio, good manure proved to be worth $3.75 a ton in terms of crops produced.

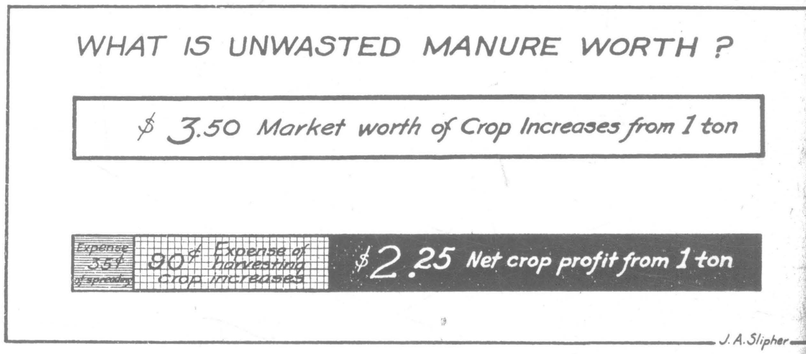


FIGURE 2

EQUAL TO TWO WHEAT CROPS

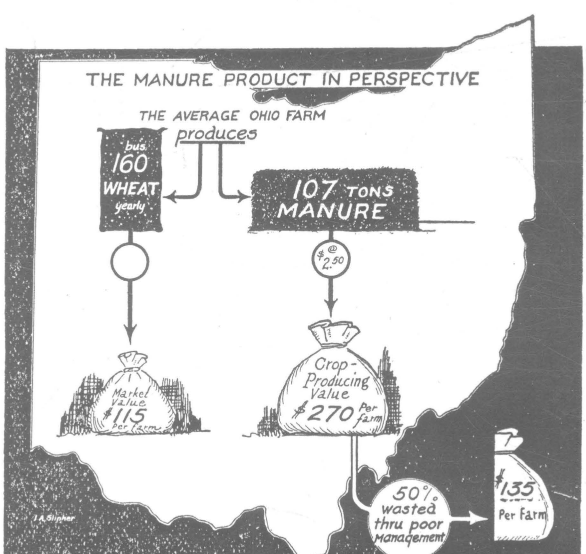


FIGURE 3

The manure pile swells the farm income more than is generally realized. Livestock on the *average* Ohio farm, consisting of 92 acres of land, produces about 107 tons of manure through the stable each year. Evaluated at $2.50 a ton (the average ton-value found by 31 Ohio tests as already pointed out) the stable-produced manure on the *typical* Ohio farm is worth conservatively $270. That is, it will produce crops worth that much. This

* Corn, 55c bu.; wheat, 80c bu.; hay, $10 ton; straw and stover, $1.75 ton.

same *average* Ohio farm produces a $115 wheat crop. Accordingly, on the Ohio farm the annual manure product, when unwasted, is worth two wheat crops as illustrated by Figure 3.

Benefit Is Additive

Betterment built into soil by manure proves lasting. In practice, a consistent, long continued input brings on a progressive rise in yield trend. Bearing out this principle are the 40-year findings of the Pennsylvania Station, in which the acre-worth of crop increase from manure in each of the last 15 years amounted to $16.50 as contrasted to $9.55 during the first 12 years. Similarly, at the Ohio Station, a cumulative rise was experienced from a standard application of manure on a corn-wheat-clover rotation, as evidenced in Figure 4.

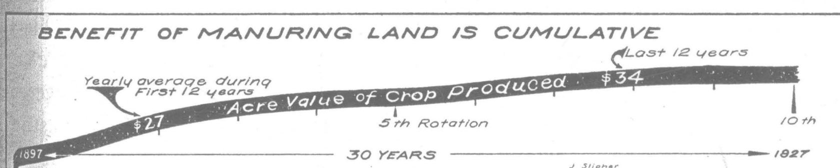


Figure 4

Productivity Index for Manure

The "soil productivity index"* value assigned manure is + 0.15 (credit) a ton. This credit factor, being based on the measured field response of crops to manuring, represents the collective betterments to soil: humus making material added, nutrients supplied, strengthening of tilth and water retention, and biologic stimulation. It applies to freshly produced manure or that so protected as to safeguard its perishable character.

Contrariwise, waste of manure is discounted — 0.07 (debit) a ton for that produced in an open lot or exposed outside for three or more months before distribution on the land.

Employing these factors to the manure resource of the farm, its appraisal on a point basis for a given year might appear thus:

Credit: All manure produced...... 300 tons × +0.15 = +45 points
Debit: Part subject to wasting..... 200 tons × −0.07 = −14 points
Net: Actual contribution to soil productivity........ = +31 points

Estimating Expected Tonnage

To estimate the quantity of manure (including litter) to be expected from the farm's livestock, one may resort to either of two convenient methods, namely:

(a) Tons of feed (barn-dry) × 1.7 = ——— tonnage of manure

or (b) Tons of livestock × months fed + tons of bedding
= ——— tonnage of manure

* For a working familiarity with the arithmetic manipulation of these and related soil productivity factors, see Ohio Extension Bulletin 175, "Our Heritage—The Soil," and Ohio Extension Leaflet, "The Soil Productivity Balance of Cropland."

While different kinds of livestock yield unlike amounts of excrement and of unlike composition, the unlikeness is deceptive, superficial. In effect, all are diluted much or little with water, rendering some two to three times richer in organic matter and nutrients than others (see Table I). However, equal weights of livestock, regardless of kind, produce virtually identical amounts of organic matter yearly (see Column 2, Figure 5). One ton of livestock voids 1 ton of excrement a month in terms of material adjusted to a water content of 65 per cent (see Columns 4, 5, Figure 5). This is the basis for method *b,* page 5. By this method, the answer is in terms of manure of approximately equivalent composition with respect to percentage content of organic matter and total nutrients.

Table I.—Organic Matter and Nutrients in 1 Ton of Excrement

Livestock	Water	Organic Matter	Fertilizer Nutrients		
			Nitrogen	Phos. Acid	Potash
	Per Cent	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Poultry . . .	55	900	20	16	8
Sheep	66	680	21	6	19
Horse	74	520	13	5	15
Cow	83	340	10	4	7
Hog	86	280	10	7	13

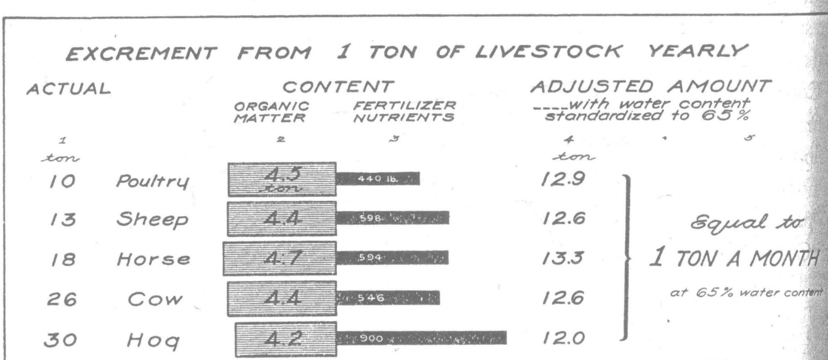


FIGURE 5

Wise Management Doubles Returns

Because it can be converted into salable crops, manure is indirectly marketable. However, under common methods of careless handling about the barn and the delay in spreading, as much as one-half the strength of manure is lost before the material reaches the field (see Figure 3). This heavy wastage—equal to the complete loss of a wheat crop—is needless; it is preventable.

To secure the full value from manure, necessitates systematic management in barn and field. Practicing protective measures in the barn during production, safeguarding during temporary storage, and placing manure at the most effective points in the rotation constitute good management.

• •

Barn Management During Production

To produce manure of unimpaired quality requires certain protective measures. From a manure-saving standpoint, safe stable management prescribes the following standard measures during production:

Protective Measures

1. Adequate absorbent
2. Regular phosphating
3. Firm tramping
4. Complete shedding
5. Water-tight flooring
6. Little or no open-lot

Without these, manure will lose fully one-half of its strength during production. With them, it can be produced with only slight losses. Each one is practical and profitable. All are demanded for full protection.

500 Pounds of Litter for 1 Ton Excrement

For each ton of excrement voided, 500 pounds of litter are needed to act as an absorbent in retaining the liquid. Of excrement, 4 pounds in 5 are water or liquid.

About half of this liquid is held by the organic matter of the feces (see Figure 6). The other half, however, amounting to 800 pounds in each ton of excrement, is free to move and percolate out, carrying with it two-fifths of the total plant nutrients recovered from feeding. The function of litter is to standardize the water content of the manure at about 65 per cent.

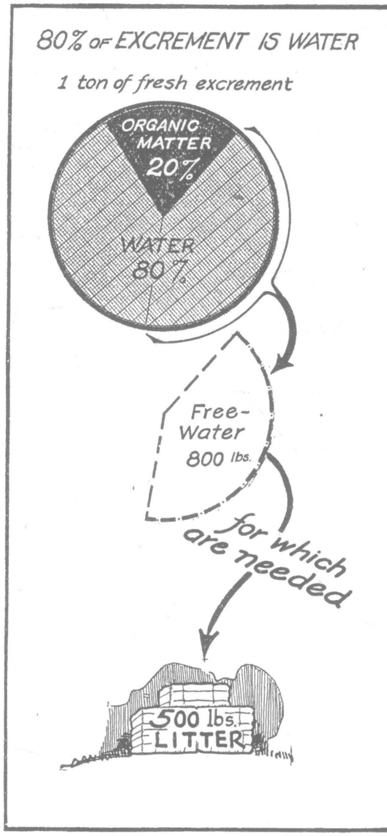


Figure 6

Double Duty Absorbents.—The amount of absorbent to use is influenced by the kind and condition of material. Ordinary wheat straw takes up about twice its own weight of water (see Figure 7). Oats straw excels it slightly, while cut straw has double the water capacity of whole straw. This fact would argue for the advisability of cutting straw in case the supply is inadequate. Some dairymen are doing this now. Cornstalks in a whole condition are poor absorbents, but when shredded, exposing the porous inside portion, prove highly satisfactory for use in the stable. The up-take of moisture by sawdust is equal to that of cut straw and its use is found as satisfactory. Convenience of handling appeals to the user.

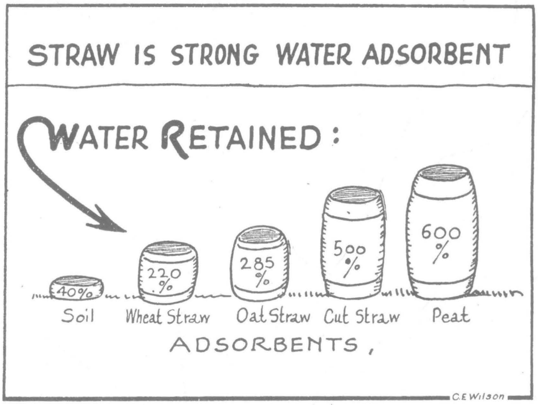


FIGURE 7

Standard Allowances.—Straw, equal to 25 per cent of the weight of excrement, will safely handle the free liquid. Some excrements are more watery than others, necessitating a more liberal proportion of absorbent. Standard allowances of straw absorbent for each head of livestock are as follows: 9 pounds daily for cow; 7 to 10 pounds daily for steer; 10 to 15 pounds daily for horse; 1½ pounds for hog; and 1 pound for sheep. Insufficient absorbent accounts for much leakage in the stable and between the stable and the field. Skimping in the use of litter is false economy.

30 Pounds of Phosphate for 1 Ton of Manure

Spreading superphosphate on manure during production safeguards against the loss of ammonia (Figure 8). All manures ferment to a greater or less degree with the release into the atmosphere of ammonia gas, containing the all-essential growth-producing nutrient—nitrogen.

The pungent odor of the horse stable is nothing other than ammonia

FIGURE 8

gas. From one-fourth to three-fourths of manurial ammonia may escape through this channel.

In view of the fact that to replace this lost ammonia (nitrogen) through the fertilizer bag will cost from 8 to 12 cents a pound, the use of some preservative to reduce the wastage is likely to prove surprisingly profitable.

Superphosphate Highly Effective.—The most effective preservative is ordinary superphosphate. Other materials easily procurable and convenient of handling are helpful in varying degrees, as revealed in Figure 9. Rock phosphate has been employed to some extent in the past, but it proves inferior to superphosphate. In connection with the use of preservatives, it should be understood that their function is not to prevent fermentation but merely to trap and hold the ammonia gas resulting from fermentation.

Besides its ammonia-saving duty, the phosphating of manure is justified in a second benefit—namely, its reinforcement of the low phosphate content. (For full discussion of this feature see page 30.)

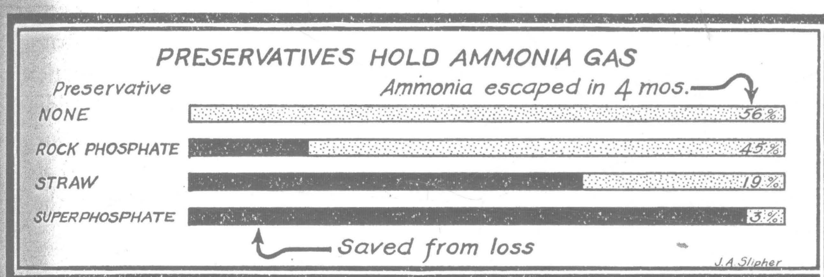


FIGURE 9

Standard Allowances.—A standard allowance is 30 pounds of superphosphate per ton of manure. "Hot" or readily fermentable manures, such as horse and sheep manures, need more liberal treatment, about 40 pounds. On "cold" manures—cow, steer, hog, and poultry—30 pounds suffice. From ½ to 1 pound daily for horse, cow, steer, and other animals in proportion to their weight is a good basis.

How to Apply.—The phosphate protection measure is limited strictly to that manure produced and kept under cover until hauled to the field. With horses the application is best made just before cleaning the stable. Dusting in the gutter of the dairy stable either before or after cleaning is equally satisfactory. For manure that is allowed to accumulate, as in the cattle-feeding barn, it will be found more convenient to give the phosphate treatment periodically once a week or preferably just previous to each bedding of the lot. Temporary storage of manure presents the most urgent need for admixing a preservative, since the conditions are, at best, semi-favorable to fermentation.

Tramping Curbs Air Loss

Tramping manure by livestock, making the mass dense and tight, excluding the air, measurably curbs fermentation. Cutting down the air supply slows up the activity of the decay organisms responsible for the release and consequent waste of ammonia gas. Under barn conditions, tramping proves a strong curb on ammonia release.

The Pennsylvania Experiment Station found that the loss of ammonia in 2 months from untramped manure under cover and on a fair floor was 34.[illegible] per cent, and from tramped manure the loss was only 5.7 per cent. Thus the tramping saved five-sixths of the loss of ammonia. Obviously, in the packed manure, fermentation was at very low ebb, as evidenced by only 6 per cent loss of ammonia.

By the combined control offered by tramping and phosphating manure one can reduce the decay menace to a minimum.

Putting All Manures Under Foot.—Tramping is not only effective in results but practical of application. In the cattle-feeding shed or barn, the benefits of tramping are realized to the fullest. Equally good facilities and results are being had in the newer type of dairy barn layout by providing an accumulation pen where the cows run loose at all times except when being milked and fed grain. Here the bulk of the manure is produced into a dense mass. Furthermore, the safe protection during accumulation permits the time of hauling to be more elastic.

Layouts with Accumulation Pen.—The plans sketched in Figures 10 and 11 are designed for this improved scheme of management. The dairyman operating under no legal restrictions as to manure disposal will find the rectangular plan suitable and simplest.

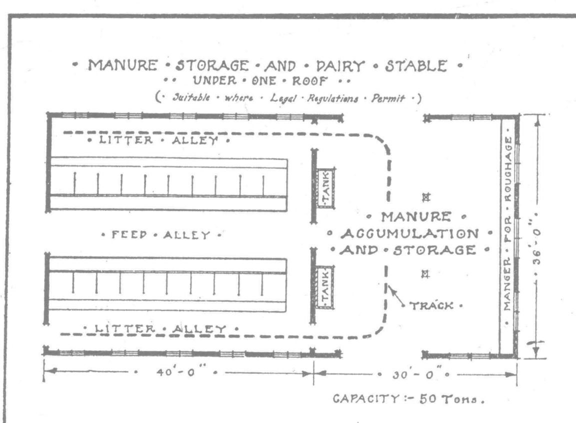


FIGURE 10

On the other hand, the ell-shaped barn offers the market-milk producer a feasible arrangement that cares for both cow and horse manures and meets the legal requirements for distance. Incidentally, these layouts facilitate feeding of roughage and supplying of litter, which are mowed conveniently above.

These schemes are not confined to new barns, but are equally applicable to old ones. By rearranging the inside of most existing barns, suitable quarters can be made for accumulation of manure under foot.

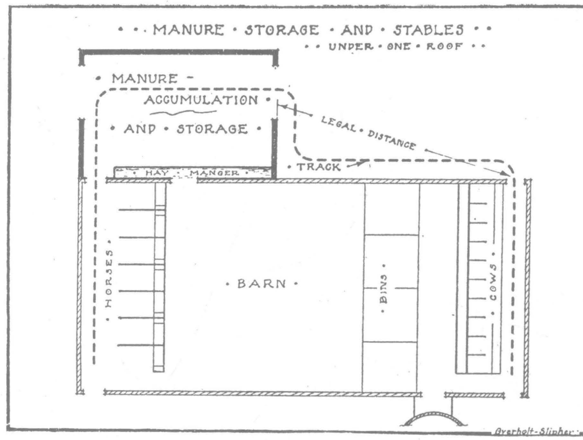


FIGURE 11

SHEDDING THE BIGGEST SAVER

Shedding protects manure more than any other single measure. It is the main bulwark. It not only cuts off leaching but stabilizes the moisture content so that the mass will pack firmly—an achievement impossible in the open lot. Rainwater acts as a vehicle, carrying away organic matter and plant food in solution. Under open lot conditions, manure is washed by 13 inches of rainwater during the four winter months. This amounts to 300 tons of water on

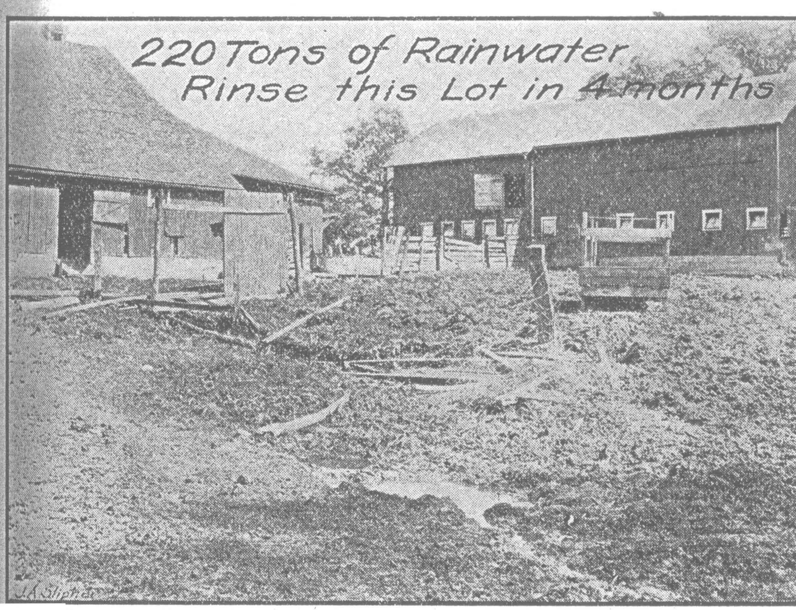


FIGURE 12

a lot 1/5 acre in size. Such a volume of water can easily and thoroughly wash out the 40 per cent of liquid plant nutrients in fresh manure in spite of a reasonable supply of litter (see Figures 12, 14, 23, and 24).

Shedding Doubles Strength of Manure.—The marked superiority of shed manure over that produced in the open lot is accurately measured by the response of crops to each. At the Germantown Test Farm, Ohio, open-lot manure returned a net value of $1.70 per ton as against a net value of $3.30 per ton for shed manure, over a period of 20 years' testing. Rainwater took toll of half the strength of the manure. For every 100 tons of manure protected, roofing netted $160. Because it is wasteful of manure, the open lot should eventually go into the discard.

Shedding Manure Lot can be Inexpensive.—By rearranging the interior of many barns, much can be done toward producing all manure under cover. This is especially feasible on farms carrying few livestock. To accommodate the needs met with on strictly livestock farms, the construction of additional shelter is advisable. Such extensions can generally be made at a minimum expenditure by attaching a shed to the side of the barn and leaving the broad side open. In fact, this latter feature is most desirable in order to get direct sunlight under the shed. A simple but ideal shed of this type is shown in Figure 13. It has a southern exposure with a 14-foot elevation at the eave, admitting the sun's rays fully two-thirds of its depth. The manure along the open side is retained by a 4-foot concrete wall and the steers are kept inside where all straw and waste roughage are put under foot. In a 6-months feeding period, this shed (24 by 100 feet) turns aside 160 tons of rainwater.

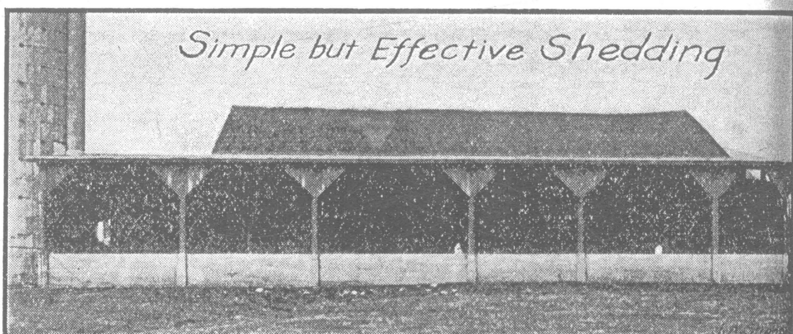


FIGURE 13

WATER-TIGHT FLOORING PAYS

Water-tight floors save manure. They pay. From a manure-saving standpoint, no horse, cow, hog or cattle barn is safe without an impervious floor. Laden as it is with 40 per cent of the plant nutrients in manure, urine merits bottle-tight protection (see Figure 14).

Concreting for Manure's Sake.—In dairy stables, concrete gutters and floors retain the urine until absorbed by the litter. Unless rendered water-tight with pitch, plank floors under cows or horses are inferior to earth ones.

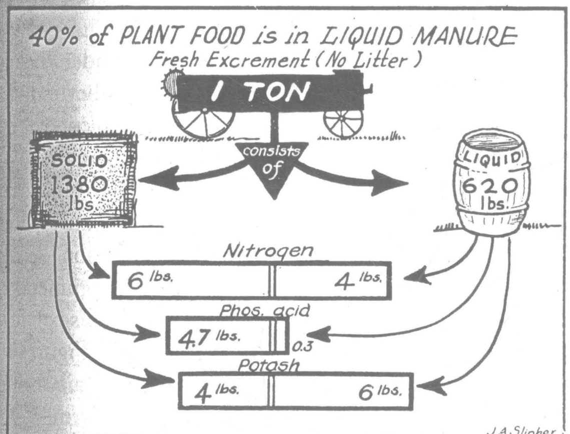


FIGURE 14

By replacing a loose, plank floor with concrete, the Ohio Experiment Station saved liquid plant nutrients at the rate of 16 pounds of nitrogen and 24 pounds of potash per cow per year. To restore these losses by means of the fertilizer bag would cost about $3.40 at modern prices. Thus the savings effected in 12 months paid for the new flooring. Such a betterment to the dairy equipment means an added net income of $75 yearly for a 20-cow herd.

Concrete Floor Saves in Steer Shed.—Contrary to popular belief, tramped manure in the steer shed does sustain loss of liquid. Though on a hard earth floor and in spite of liberal bedding, manure surrenders water or liquid to the soil. The manure is much wetter than the soil beneath—a condition that causes the stronger capillary power of the soil to pull water from the manure. This sapping action has been found to extract 15 per cent or 1 ton of the yearly liquid voiding of one steer.

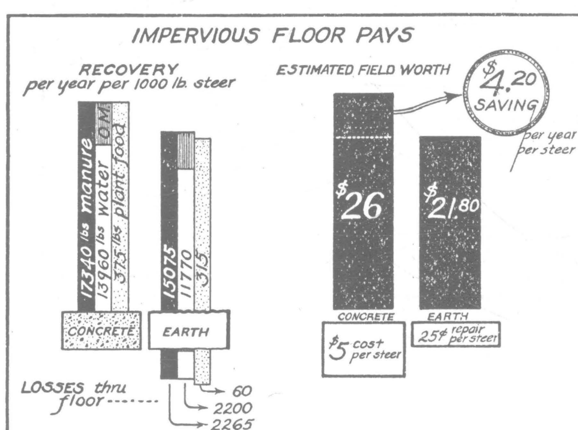


FIGURE 15

Findings in a carefully conducted test by the Ohio Experiment Station, using two lots of steers (fed identical rations), one test on concrete, the other on earth floor, showed less plant nutrients in the manure produced on the earth floor (see Figure 15). Concreting saved 60 pounds of plant nutrients having an estimated field value of $4.20 per year per steer—enough to pay for concreting the floor. For every carload of cattle fed, this would mean a clear saving (after the first year) of about $100 a year.

Pan Type of Floor for Covered Lot.—In producing manure under shelter having an open side, the lateral "creep" outward moves several tons beyond the range of protection. To prevent this as well as losses by downward movement, a pan type of floor construction seems advisable. Recommended plans, having this pan feature, appear in Figures 16 and 17, the details being shown in the former. As noted, the floor is depressed below the immediate ground level. Continuous walls confine the manure to the shed not only on the back side but on the open side as well.

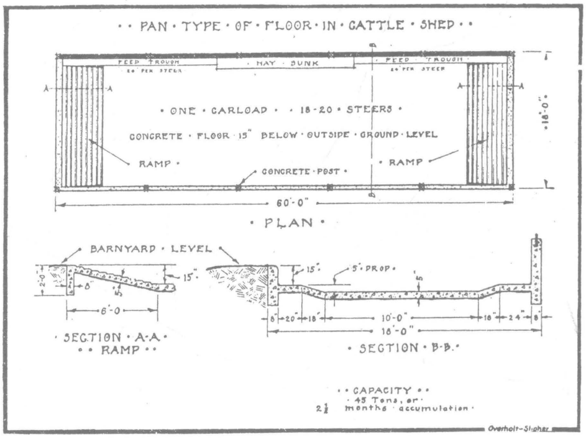


FIGURE 16

Ramps at either end, over which the manure spreader passes lengthwise of the shed, hold the manure in (see Figure 16).

On the outside, the ground slopes gradually away from the wall, sinking to the level of the floor at a fair distance from the structure. By this design the manure and its liquid are safely bottled up, while rainwater is kept out.

The pan-type floor is applicable to any quarters where livestock run loose under shelter.

Having a capacity for 2 months' accumulation, a floor of this type affords full protection between periodic haulings during the winter months.

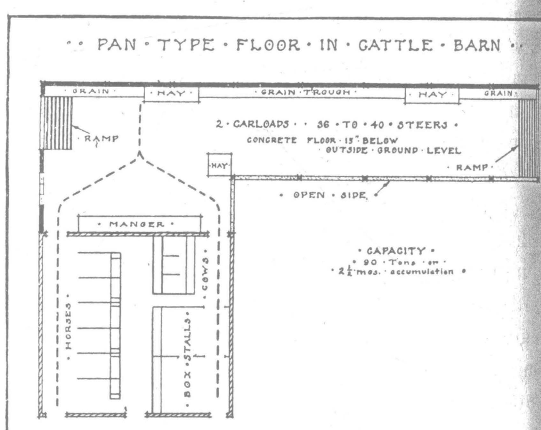


FIGURE 17

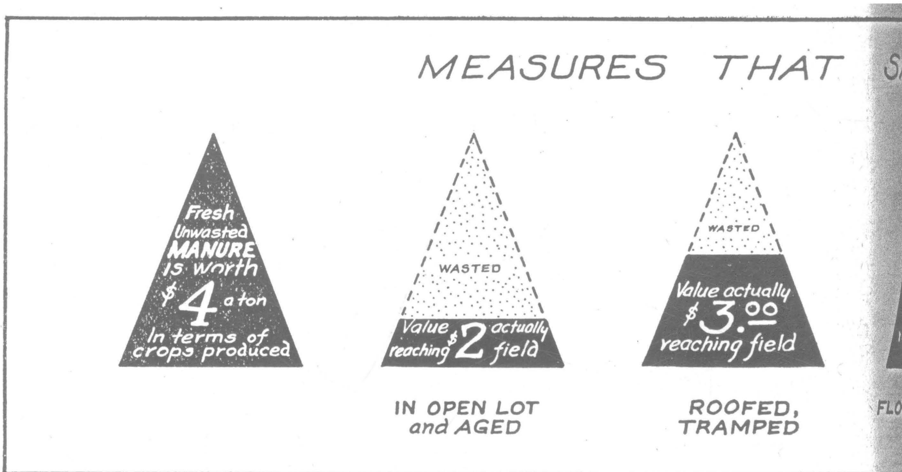
The smaller the open lot is, the better. Large lots are merely huge washing basins wherein to rinse out the easily removable constituents of manure. As a matter of fact, most lots are two to five times larger than required for the comfort of the animals.

Big Lots are Big Rinsing Tubs.—To have over-size lots means having no more than a thin blanket of manure which receives a drenching with 13 inches of rainfall in 4 months and consequent removal of the soluble, choice part of the ingredients. On the other hand, paring down the size of the lot reduces the volume of water that needs go through the same mass of manure. Shrinking a 1/10-acre lot to one-third that size reduces the leaching water from 150 tons to 50.

Fencing out 100 Tons of Water.—Lopping off a part of the lot with a fence cuts off 100 or more tons of water. An allowance of 60 square feet of space for each head of cattle is sufficient. Thus, a space of 25 by 30 feet will accommodate 10 cows. By bringing the fence up close around the straw pile or fodder racks, and working the straw under foot, big savings can be made. In this way, as much as 2 or 3 feet of depth of manure is possible. In great depth there is much saving. However, unless the run-off of the barn roof has been taken care of by good spouting any efforts toward saving in the barn lot are partly defeated.

Open Lot Only a Makeshift.—Even with the restricted lot, much waste of manure goes on. Not until all rainwater is excluded by roofing can complete protection obtain. For that reason, the open lot must be regarded as only a makeshift—a temporary arrangement against the time when roofed quarters for all livestock can be completed. Reducing the open lot is one step toward better manure; shedding on a tight floor is the next one.

In view of the huge volume of water impounded, concreting the open lot is a most questionable venture. It fails to get at the root of the trouble, namely, the exclusion of rainwater from the manure. The logical order is roofing first, the flooring second.



Barn Manageme

The problem of handling manure after production is a large one. To get manure on to the land unimpaired in strength requires the best of management. Like fruit, manure is perishable. Aging saps its strength, while air and water play havoc with its substance. To safeguard against these dangers, good management prescribes (1) prompt hauling to field, or (2) safe temporary storage.

Hauling Promptly to Field Best

Spread on the land, manure is in its safest place. Hauling fresh manure promptly and regularly to the field forestalls wastage by aging or weathering

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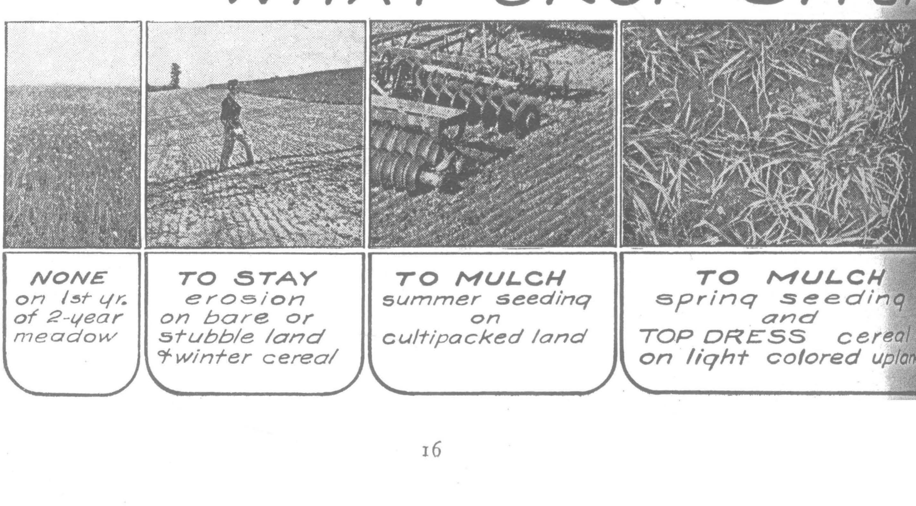
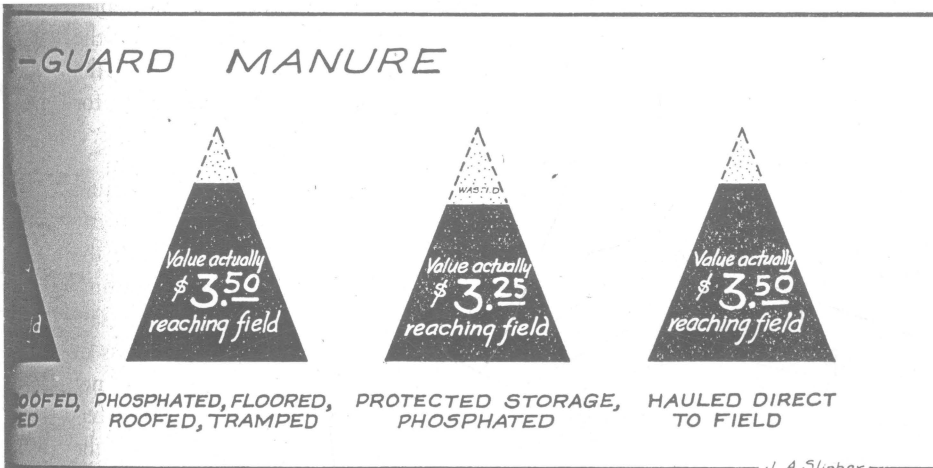


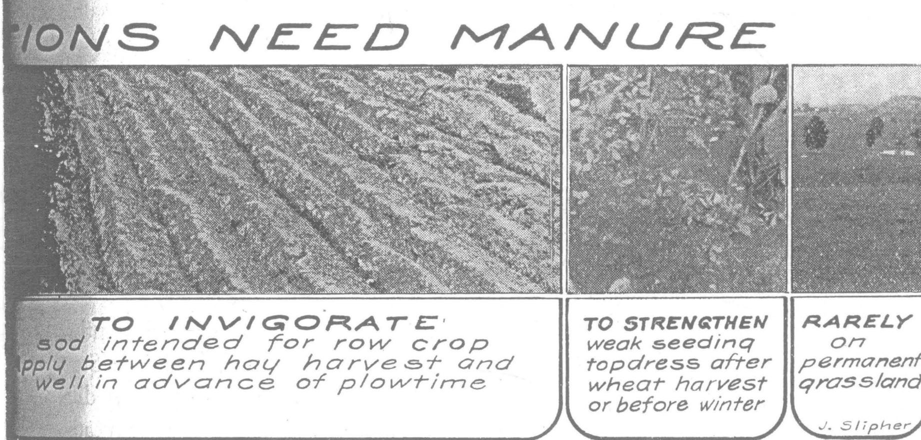


After Production

(see Figure 20). The elusiveness of ammonia in summer and the excessive rinsing of exposed manure in winter leave no alternative but hauling (or rigid protection under cover).

The urgency of avoiding losses to manure makes it desirable that the manure spreader be kept in almost daily operation. In fact, the daily plan of work on the farm may well provide time for this duty.

Leachings Securely Trapped in Soil.—Little waste occurs in the field. What the manure loses the soil gains (Figure 21). Leachings pass directly into the



ground and are held securely until used by plants. In its capacity as an absorbing agent the soil filters out the substances washed from the manure by the rainwater. The capacity of the soil to hold them exceeds by several times the total quantity carried in manure. Moreover, the action is rather rapid; for example, ammonia is trapped within 30 minutes after entering the soil mass.

Drying a Benefit in Disguise.—The rapid drying of scattered fresh manure is a benefit. Dried manure is safe from decay or fermentation. Since decay progresses only when a moderate amount of moisture is present, changing the condition to either extreme (dry or wet) stops decay. A few hours of sunshine dries the finely divided fragments of machine-spread manure, making it safe against air losses. The shriveling of the material is merely due to the loss of water, in the same manner that a sponge contracts on drying, and should not be interpreted as a sign of waste. Redrying after rains in summer holds fermentation at low ebb. In winter, the low temperature in the field keeps the decay organisms dormant.

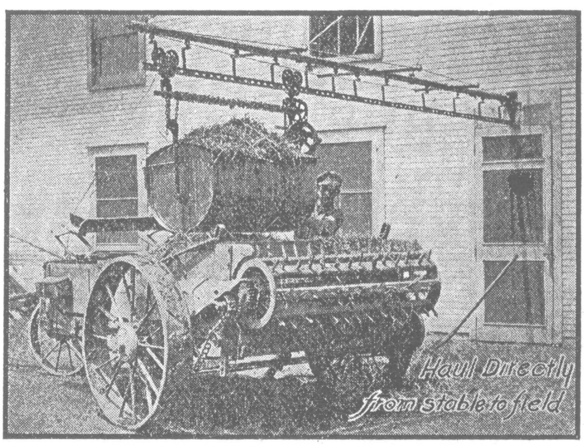


FIGURE 20

Safeguarding Old Manure in Field.—With old manure the case is different. If the manure has heated or fermented before hauling and spreading, then drying in the field will occasion heavy losses of ammonia into the atmosphere within a period of two days. The farmer may resort to either or preferably both of two safeguards in spreading old manure, especially in warm weather:

1. Previously mix superphosphate with it as set forth on pages 8 and 9. It is obvious that the use of the phosphate preservative lends flexibility to the time of spreading manure.

2. Defer spreading until just before plowing or disking, since even a small and immediate covering of soil will catch and securely hold the loose ammonia.

Security Proved.—Evidence of the security of manure spread several months ahead of plowing under for corn is reported by the Maryland Experiment Station, where winter-spread fresh manure gave 12 bushels more corn than did manure of the same condition and rate applied in April. Thus, prompt spreading not only forestalled losses at the barn, but actually brought improved efficiency in the field. (Limitations as to soil type and other circumstances on time of application are discussed under the heading of "Field Management," pages 23 to 30.

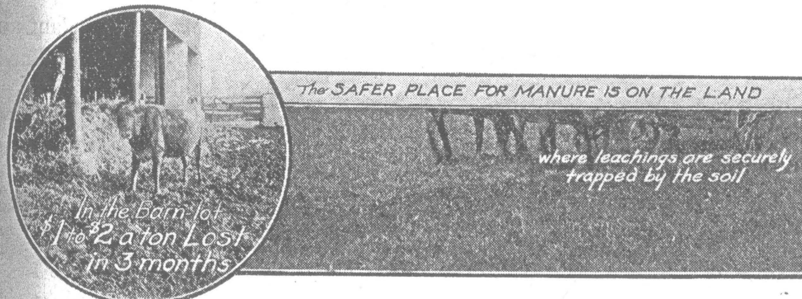


FIGURE 21

Making Temporary Storage Safe

Provision for temporary storage is necessary. It bridges the gap during those periods when unavoidable conditions, such as wet field and labor congestion, make regular hauling impractical or inadvisable. If direct hauling is practiced whenever possible, only a part of the manure need be shunted into temporary storage. Without protection, manure held a short time undergoes severe losses (see Figure 22).

FIGURE 22

Substance Shrinks 60 Per Cent in 3 Months.—Manure exposed to air and water in the open loses as much as 60 per cent of its organic matter in three or four months. Aging exacts a heavy toll as shown in a test at the Dominion Experimental Farms, Ottawa, Canada, in which a 1:1 mixture of cow and horse manures was piled loosely without protection above or below, with the results as illustrated in Figure 23.

A like exposure of steer manure for 3 months at the Ohio Experiment Station occasioned a 40 per cent loss in organic material. Horse manure has been found to shrink 57 per cent in mass due to 5 months' weathering. On the basis of a 10-ton application per acre, these amounts of shrinkage mean denying the soil 3000 pounds of organic matter and its resulting benefits to the physical and bacterial properties.

Half of Plant Nutrients Escape in 3 Months.—The fate of the plant nutrients in unprotected manure is no less serious. Fully one-half of them disappear in 3 months. An exposure of 2 months entailed losses of 51 per cent of the nitrogen, 46 per cent of the phosphoric acid, and 52 per cent of the potash from fresh manure at the New Jersey Experiment Station.

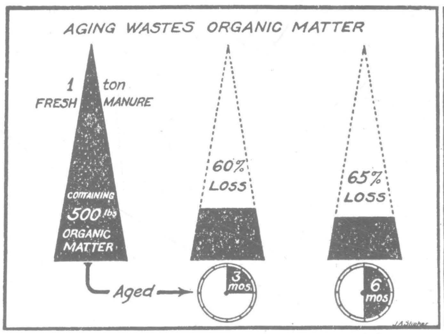


FIGURE 23

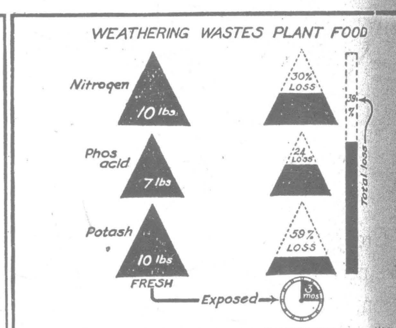


FIGURE 24

Figure 24 presents findings obtained by the Ohio Experiment Station in a trial with stall-produced steer manure that underwent weathering in the barn lot, the losses averaging 40 per cent. On farms where manure remains outside for longer periods, especially during warm weather, the wastage will run much higher, easily amounting to 60 per cent of the nitrogen, 40 per cent of the phosphoric acid, and 65 per cent of the potash. Much of this loss is of the soluble, and hence more valuable, part of the plant nutrients.

Unweathered Manure Superior.—The superior strength of fresh manure over that impaired by weathering is well measured by the response of crops. Fresh manure excels the altered product by one-fourth to one-half. In New Jersey, the fresh product registered 53 per cent greater effect on crop yield than the leached material over the 3 years immediately following application. An advantage of $1 per ton in favor of fresh manure as against the same manure exposed to the weather for 3 months, has been demonstrated at the Ohio Experiment Station.

Accumulation Pen in Double Harness.—Good indoor storage facilities are provided by the accumulation pens already discussed (p. 10). Farms equipped with these do not require an additional structure specifically designed for manure storage. Removal of fresh manure from accumulation pens as fast as condition of fields and labor will permit is advisable.

"Safe Shelter" Unit Combines Protection and Convenience.—In the absence of accumulation quarters in the barn or shed (see Figure 25), a special storage unit becomes necessary. Such circumstances make it an indispensable adjunct to the stable.

FIGURE 25

To fully protect manure the structure must have three features: a roof, a water-tight floor, and four continuous walls. To be fully satisfactory, however, the structure must offer more than safe storage (Figure 26). Above all, it must be convenient. To that end, its convenient arrangement with reference to the stable is all-important. Lastly, it should also house the manure spreader.

FIGURE 26

What would seem to meet these combined requirements is the basic plan sketched in Figure 27. As noted, this attaches to the barn with a coupling that shelters the manure spreader close at hand, yet having space enough for the passage of work horses to and from the stable. By this arrangement, the manure can be dumped optionally into the spreader or storage bin. The ease of hitching to the spreader ought to encourage its more frequent use.

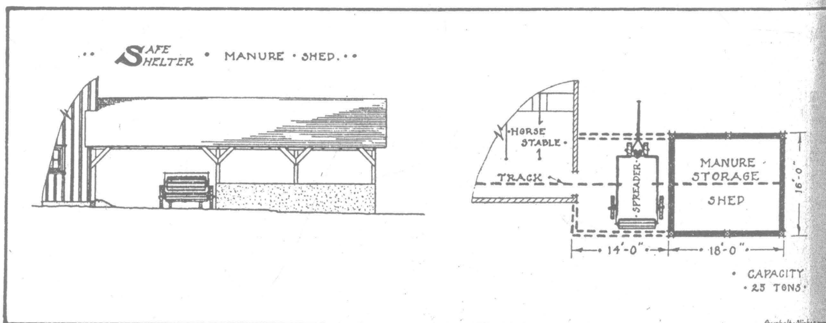


FIGURE 27

The open sides of the bin permit of loading from the four sides, thus shortening the forking distance. Being of the unit plan structurally, the bin proper may be enlarged by successive bents as needs require. The overhead cost of storage (to cover interest, depreciation, and tax) would pro rate about 15 cents per ton of manure stored.

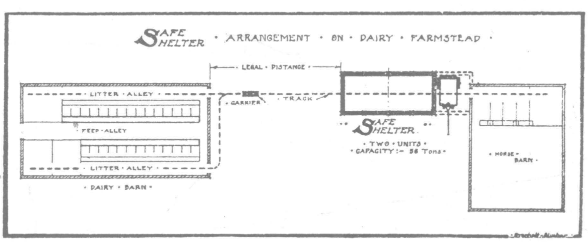


FIGURE 28

In fitting the "safe-shelter" plan into the farmstead, it seems logical to attach it to the horse stable.

By proper location of the dairy barn or hog house they can be jointly served by the same storage bin. See arrangement in Figures 28 and 29.

Incidentally, the joint storage of "cold" and "hot" manures equalizes their water content with mutual advantage.

The use of phosphate (as set forth on page 8) is especially urgent in connection with temporary storage.

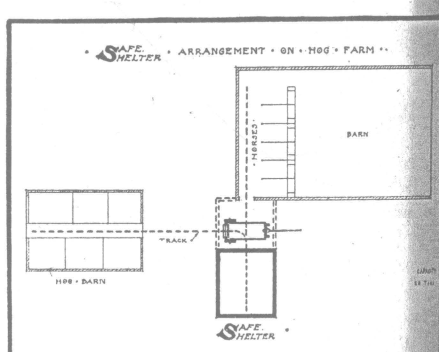


FIGURE 29

Field Management of Manure

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Good management does not stop at the stable door. It extends to the field as well. The manner of using manure in the field has much to do with getting the full worth out of each ton.

Circumstances attending the starting of legume crops, of strengthening the growth of seedings at a critical time, of the efficiency of small vs. heavy rates, of protecting soil itself, of retaining water on and in soil, of unlike need for manure on the part of different sorts of soil impose on the farm manager the exercise of discrimination in assigning manure to field, crop, and land area.

Allocation of Manure to Crop Situations

All crops respond to manuring. Some do more so than others. Crop situations affording opportunity to utilize manure are chiefly: (1) row crops, (2) applying well ahead of plowing, (3) spring seeding, (4) summer seeding, (5) weak seeding, (6) erosion, and (7) grassland (Figure 19).

Serving Row Crops.—Of the four functions of manure, outlined below, all operate advantageously in soil growing row crops.

1.—Loading the soil with manure preparatory to the row crop provides much humus-making material at the opportune time; because it comes at the time of heaviest destruction. As much as 4,000 to 7,000 pounds of soil organic matter may be destroyed (by decay) during the season. To replace it, the input by manure supplements the backlog of organic matter built into the soil by root material in the sod being plowed.

Turning the plow layer affords the opportunity of placing manure in contact with the plow sole, the position for its efficient functioning. Here it benefits from evenness of moisture supply and aeration, and releases its load of nutrients in the most favorable moisture content for ease of uptake by the crop. As with plow-sole placement of fertilizer, plow-under placement of manure capitalizes on the favorable moisture condition at the bottom of the furrow.

2.—Water retention in the soil is swelled by the organic matter. At the Connecticut Station, well manured land retained 55 tons more film moisture in the plow layer of an acre during a drouth period than did adjoining land well fertilized, but unmanured (Figure 30). Similarly, a 32-ton advantage for manure was had at the Rothamsted Station, England.

Figure 30

3.—Coincident with its decaying, a fraction of the load of nutrients brought to the soil in manure are yielded up to the crop. Row crops are greedy consumers of nutrients and their total uptake is large. Each bushel of corn takes from the soil 1½ pounds of nitrogen, ⅖ pound of phosphate, and 1 1/10 pounds of potash. About one-fourth or one-third of the 10 pounds of nitrogen, 5 pounds of phosphate, and 12 pounds of potash, normally in a ton of unwasted manure, are delivered up to crops in the immediate rotation receiving the application.

4.—Decay organisms, transplanted to the soil by additions of manure, improve the digestive process of the soil, enlivening the decay of old and partially spent remains already in the soil.

Apply Well Ahead for Full Returns.—Applying manure well ahead of plow time favors greater crop returns. In practice, that means starting treatment of meadow sods (intended for corn) after hay harvest and continuing as the volume of manure permits. Since plants in second-year meadows (2- and 3-year meadows are the desirable and coming cropping pattern in Ohio) are responsive to nutrient feeding, manure applied to older meadows invigorates the turf, thereby building up a heavier sod, more go down material, and better tilth in readiness for row crop. Because time is needed in that process, advance treatment proves advantageous.

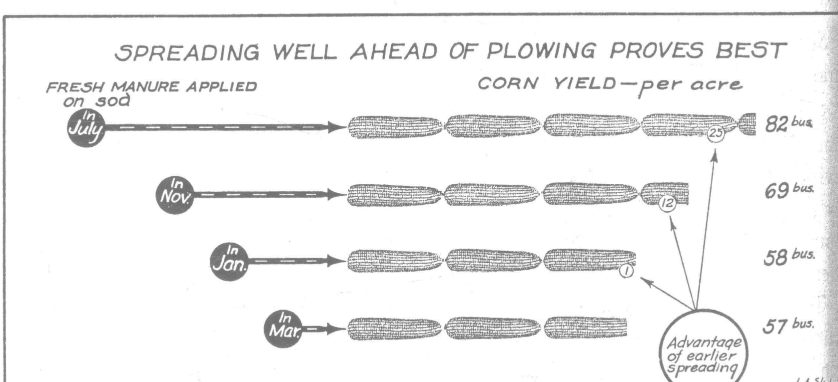


FIGURE 31

In a test at the Maryland Experiment Station, fresh manure was placed on four strips of sod land as follows: on one, in July; on another, in November; on a third, in January; and on the other, in March. All strips were plowed simultaneously in April. The response of corn to the time factor appears in Figure 31. These findings argue for getting the manure on the land a few months ahead of corn planting.

Mulching Spring Seeding.—The one best means of starting seedings of legumes or grass is a surface dressing of manure. Its virtue lies in its physical action of holding moisture at the ground surface enough to germinate the seed and prevent undue dryness and hardness of soil surrounding the seedling.

The less friable the soil the greater the need for the benefit to be had from mulching. Accordingly, upland, light-colored soil occupied by winter cereal presents a "must" situation for this measure. Barely less needy are sites of badly degraded land being put to spring cereal and seeded.

A dressing of four loads suffices. The coarseness of division or extent of decay are unimportant. With spring cereal, the treatment follows seeding; for winter ones, the top-dressing may be made any time during late fall or winter. On sites where wheat is likely to "lodge," avoidance of the hazard requires that the dressing be very light, or applied early, or contain much straw, or omitted.

Aside from concern over the seeding, benefit to wheat itself may justify top-dressing. On upland, light-colored soils of middle and southern Ohio, a blanket of manure softens the shock of temperature change in the soil. It insulates against extremes of temperature associated with alternate freezing and thawing.

Mulching Summer Seeding.—Experience and tests of mulching alfalfa seeding made in midseason amply demonstrate its value in bringing stands through in dry seasons. The best procedure is to top-dress immediately on broadcasting the seed on cultipacked ground.

Strengthening Weak Seeding.—An existing seeding that lacks thrift and vigor may gain much from an application of manure after grain harvest or before the onset of winter. It supplies potash and phosphate so necessary to the young legume and nitrogen for the grass in the mixture. On the physical side, the straw and substance reduces midseason temperature of ground surface, protects against crusting, ups the intake of rainwater, and stabilizes the moisture content of the root zone.

To properly meet these several functions, six to eight loads of manure to the acre are advisable.

Staying Erosion.—Fragments of manure and straw placed on the ground surface obstruct the escape of surface water. Less movement of water means less erosion. Fields or areas lacking vegetative covering are vulnerable even though the slope is mild. Manure on sloping land in stubble, or bare, or in winter cereal, or in feeble sod, substantially lessens erosion and conserves rainwater by rendering the soil permeable at the surface.

On Permanent Grassland, Merely An Expedient.—Diverting manure from cropland to permanent grassland is normally inadvisable.

It robs cropland. Being derived from crops out of the cropland area, barn-produced manure belongs to the cropland economy. To apply manure to permanent grassland takes it from cropland, where it properly belongs. Such a system of land economy pursued over the long stretch obviously is unsound. In proportion as one indulges in it, he departs from true soil conservation.

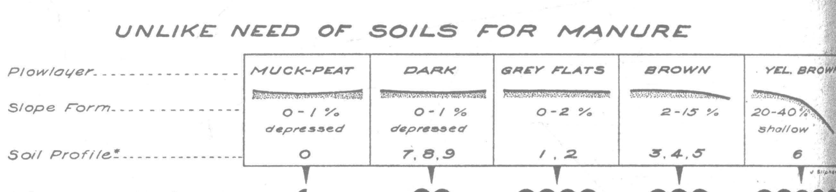
However, as an expediency measure there is justification in apportioning a liberal lot of manure to the rejuvenation of worn pastureland. Concentration of its organic matter at or in the soil surface brings into play its physical functions: mulching, moisture retention, protection of tilth, restraint of erosion, temperature regulation—with almost indispensable benefit to the seeding. Upkeep of established sods, being chiefly a matter of supplying nutrients, would better come through commercial fertilizer.

Allocation of Manure to Soil Situations

All soils profit from manuring. Some benefit primarily from one or two functions of manure, a few unequally, while others share in all.

To the unlike capacity of soils to utilize these functions, we must look for our guide in allocating the supply (in connection with the next five sections, follow Figure 32).

Shallow, Sloping Land.—Shallow soil, characteristic of sloping land, needs manure in abundance. Washing by runoff placed an extra drain on its stock of nutrients, which under virgin condition were no greater than in any other soil group. Sloping land combines the weakest retentive power for internal moisture and the greatest susceptibility to run-off. Therefore, the acme of tilth is needed. The fattening effect of organic matter from manure imparts porosity and permeability to the surface, lessening waste of rainwater needed for crops, and lends sponge-like behavior to the soil body, enlarging its capacity to hold film water. Both incorporation and top-dressing are applicable to this kind of land.



* Being the third digit in the standard number designating the sort of soil and now appearing on individual soil maps of farms in Soil Conservation Districts in Ohio.

Figure 32.

Grey Flats Need All Functions.—Ashy grey flats call for every function of manure and in the maximum degree. On farms where this soil occurs with dark land, the allocation of the stock of manure needs to be unbalanced to the advantage of the former by a ratio of 3:1.

This group shares with no other, a worse bracket of weaknesses: paucity of nitrogen, potash, phosphate, lime, and skimpy humus content. Tilth of the feeblest order mark these soils, permitting imperviousness toward water and predisposing them to erosion, however slight the slope. The nutrient deficiencies may be overcome by commercial fertilizer and lime programs, but only manure and other sources of organic matter (residues, sods) can strengthen tilth, expand porosity, fortify against hazard of drouth, and bring about normal biologic life. Here top-dressing brings positive benefit to wheat, to starting of seedings, and to young stands. Incorporation of manure yields substantial crop response and noticeably saves water and soil against run-off.

Dark Soils Profit from Nutrients.—Although contrary to popular notion, it is good practice to manure dark colored soils, but relatively light doses suffice. Six tons an acre is a suitable rate for this group where the light-colored land on the same farm is receiving 10 to 15 tons. Furnishing nutrients, especially potash and nitrogen, account for much of the uplift experienced. Secondary value lies in restocking with fresh organic matter and in prolonging friability and aeration already of an excellent order.

All-round Uplift to Brown Soils.—To the great group of brown soils, manure brings renewal to all functions. Their need of nutrients, of tilth renewal, of restocking with organic matter rests about midway between that of the grey and of the dark ones. Urgency of control over erosion and water loss exists universally. For this purpose manure offers much.

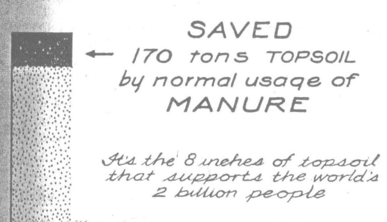


FIGURE 33

Consistent usage of manure for 42 years in a balanced rotation at the Ohio Station reduced erosion 17 per cent amounting to 170 tons an acre (see Figure 33). Applying 16 tons of manure per acre to an Iowa soil, growing continuous corn on a 9 per cent slope, saved 77 per cent of the soil loss and 63 per cent of the waste of water.

Revitalizes Organic Soil.—Muck and peat soils that become spent take on renewed life from manure treatment. Organisms transplanted from the manure revive decay and potash abundant in manure, meets muck's notorious weakness—lack of potash.

Light Applications Make a Ton Return More

Light dosages excel heavy applications in crop returns per ton of manure. In other words, the crop response from 10 tons spread over 2 acres proves larger than that from 10 tons on 1 acre. With manure, as with lime and commercial fertilizer, the all-important point is the crop increase per unit of material employed.

At the Germantown Test Farm, Ohio, a 10-ton application an acre returned $3.60 per ton of manure, as against $2.50 from a 20-ton treatment of the same kind of shed manure on an acre (Figure 34). The application went on tobacco in a 3-year rotation of tobacco, wheat, and clover grown on Miami silt loam soil, the extensive, light-colored soil of western Ohio.

Among other field comparisons, attesting the greater efficiency from smaller applications, stands the 30-year work of the Ohio Experiment Station. It shows a 24 per cent greater net worth per ton from a 4-ton as against an 8-ton treatment in a potato-wheat-clover rotation on Wooster silt loam soil. In other words, 100 tons of manure used at the lighter rate returned $93 more net profit than when spread at double the rate.

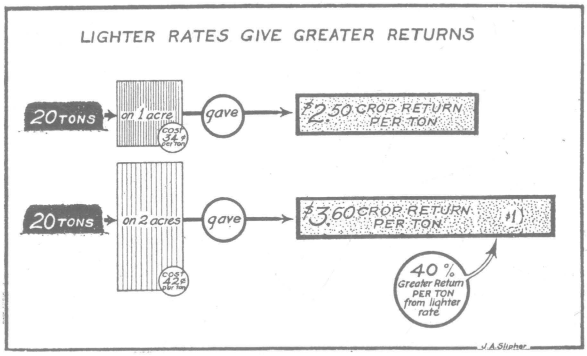


FIGURE 34

It would seem wise, therefore, to gauge the rate of application so as to extend the acreage covered for each crop. Good practice, then, prescribes covering thinly every available acre each year from the fixed volume of manure.

Frequent Use Makes a Ton Return More

Frequent small doses are more efficient than a single large application. The returns from a ton are greater. In this connection, findings of the Virginia Experiment Station are worthy of note. Sixteen tons of manure applied to corn in a corn-wheat-clover-grass rotation, were compared with 16 tons divided equally among the crops. The result was a 20 per cent advantage in favor of the divided treatment. This strongly suggests that more than one application each rotation is advisable. Usually two applications each rotation are ideal.

Full Measure from Fineness and Evenness

Good spreading—which means fineness and even spreading—brings out the full worth of manure (see Figure 35). In its stable form, manure is not a finished product. Only finely divided manure can deliver up its full measure of effects. The modern manure spreader functions as a physical conditioner, as well as a distributor, and vehicle.

Machine-spread manure, being finely divided and spread in an even coat on the ground, loses a minimum of ammonia gas, since it dries quickly, thus arresting fermentation. Moreover, it mixes more thoroughly with the plow layer upon being turned under.

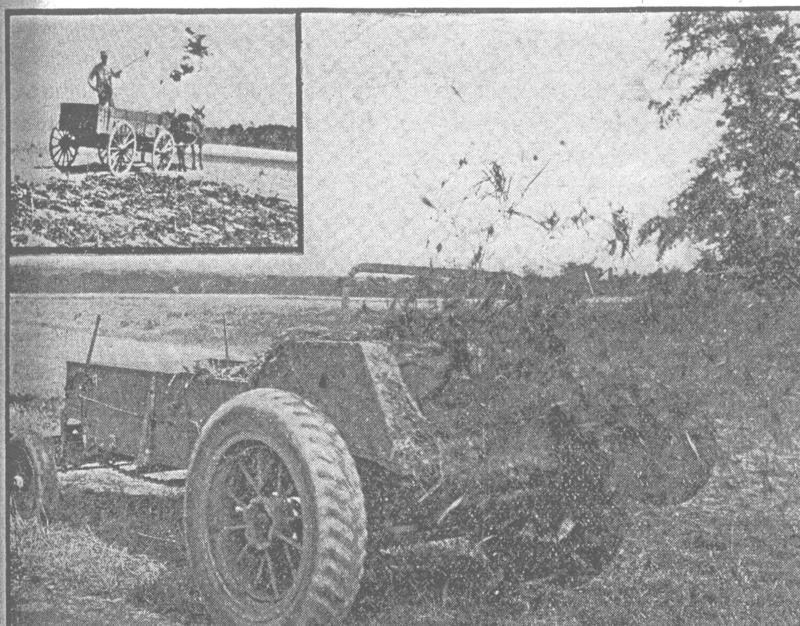


FIGURE 35

SECURELY PLACED BY PROPER PLOWING

Manure works best inside the soil. Tillage permits of and aids incorporation.

Plowing Under Usually Best.—Plowing under or thoroughly disking in after plowing fosters equally good corn growth on silt loams and heavier soil types. For sands, safety and good action require that manure be turned under. Top-dressing planted corn has proved least effective. Disking a light treatment into the surface 4 inches of land being prepared for wheat, places the manure in the best position. With grass crops, top-dressing is the only recourse, and is also quite satisfactory on wheat where winter protection is being sought.

Proper Placement by Intermixing.—Proper placement is more than mere covering. Intimate mixing is the essential objective. The right manipulation of the plow layer will yield a profile having the lower three-fourths well peppered with manure fragments. This offers the greatest number of contacts between manure and the soil. Ideal placement is achieved by disking the mass into the soil before plowing, thus multiplying the mixing process. This procedure is especially advisable when turning under manure in conjunction with a heavy top growth of sweet clover or other crop material, the decay of which manure accelerates.

Reinforcing with Phosphate Profitable

It is a good practice to mix phosphate with every load of manure. All animal manures are weak in phosphorus. Likewise, all corn belt soils are weak in phosphorus. Under these conditions, the crop suffers for want of this nutrient. The solution lies in adding superphosphate to the land in conjunction with manure.

"Killing Two Birds with One Stone."—As already pointed out, the use of phosphate on manure in the stable is advisable for the sake of preserving ammonia. This manner of use does double duty; it also raises the phosphorus content of the manure to the desired level. Manure supplemented with 30 pounds of superphosphate (20% grade) to each ton will carry to the soil about the right amount of phosphorus for the needs of the immediate crop. An 8-ton application of manure, so treated, supplies 240 pounds of superphosphate to an acre.

Three Dollars Profit from One Dollar of Expense.—Profitable returns are being had from phosphate employed as reinforcement in manure at the Ohio Experiment Station on Wooster silt loam soil, which is representative of northeastern Ohio land. In this test, 32 pounds of superphosphate (20% grade) are added to each ton of stall manure, and 8 tons of manure applied to sod preparatory to corn in a 3-year rotation with results as tabulated in Table II:

Table II.—Returns from Phosphating Manure
(Ohio Station: findings in 36-year test)

Wooster Silt Loam 8 tons applied on sod for corn	Crop Increase per Acre			*Net Return for $1 of Phosphate
	Corn *bu.*	Wheat *bu.*	Clover *bu.*	
Stall Manure plus Superphosphate.....	34	16	2120	
Stall Manure, alone..................	25	10	1280	
Gain for Superphosphate over Manure.	9	6	840	$3.33

* Corn, 55c; wheat, 80c; clover hay, $10 ton.

Although the manure itself supplied approximately 40 pounds of nutrient phosphorus to the acre, the addition of 32 pounds from the fertilizer bag proved profitable to each crop. Three dollars net profit were had for each dollar expended for superphosphate.

Expense of Protecting and Handling Manure

The expenses connected with protecting and handling manure are small. They are greatly overshadowed by the savings effected. In counting the expense of manuring land we may note the following.

Costs 10 to 30 Cents a Ton for Protection

In general, safe protection can be had for 10 to 30 cents expense per ton (see Figure 36). This protection adds from $1 to $2 to the field value of the manure. Most of the outlay is made up of interest and depreciation charges on capital invested in suitable equipment for protection and storage. Concrete floors in accumulation shed or quarters are a legitimate assessment against the tonnage of manure protected. On the other hand, the impervious floor of the dairy stable, being a sanitary measure, is to be charged against the dairy business.

Figure 36

Manure stored temporarily in a special shelter bears the full overhead charge. Little if any extra labor of handling is entailed by good stable management. Money put into protective measures returns from two- to three-fold.

Costs 35 to 45 Cents a Ton for Spreading

Few operations about the farm yield larger and more positive returns for the labor expended than does the timely handling of manure. The three- to six-fold return to be had from prompt, timely spreading may well give this operation priority over certain other chores.

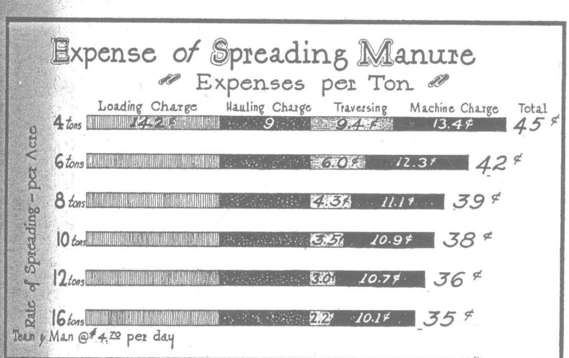


Figure 37

It costs 35 to 45 cents a ton to spread manure. The heavier the application, the lower the charge per ton. By referring to Figure 37, it is observed that four items combine to form the total expense. These are loading, hauling, traversing, and machine charge.

About 14 Cents Loading Charge.—To load a ton of manure costs about 14 cents, assuming man and team labor worth $4.70 a day, and allowing 18 minutes for loading.

9 Cents Haulage Charge.—Hauling is a flat charge of 9 cents a ton or load. Ordinarily manure is hauled about 75 rods, as brought out by a survey of 382 Illinois farms. This figure is probably not out of line for Ohio. To cover this distance, walking at the rate of 2.3 miles per hour, a team would require 12 minutes.

Less than 10 Cents Unloading Charge.—In unloading the spreader, a team will traverse an acre in about 45 minutes. The expense of this item ranges from 3 to 9 cents a ton, according to rate of application.

About 11 Cents Machine Charge.—Based on life of 9 years for the spreader, the machine charge falls near 11 cents a ton, ranging slightly higher for light applications and lower with heavy ones.

The acre-expense of applying manure, obtained by multiplying the total tonnage by the corresponding rate of application, as shown in Figure 37, ranges from $2 to $6 as set down in Table III.

Table III.—Acre-Expense of Spreading Manure

	Rate of Spreading—Tons per Acre					
	4	6	8	10	12	16
Total expense for one acre......	$1.80	$2.50	$3.10	$3.80	$4.30	$5.[illegible]

The Challenge

No other single problem on the farm presents more of a challenge to managerial ability than the handling of manure in barn and field. The wealth in manure is worth the effort to get it out. The able farmer, as described by George Washington in a letter when seeking a farm manager, is "above all, Midas-like, one who can convert everything he touches into manure, as the first transmutation toward gold."

The Ohio State University, Cooperating with the U. S. Dept. of Agriculture
Agricultural Extension Service—*H. C. Ramsower, Director, Columbus, Ohio*
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